SPECIAL ARTICLE

Annual Report to the Nation on the Status of Cancer, 1975–2002, Featuring Population-Based Trends in Cancer Treatment

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Background: **The American Cancer Society (ACS), the Centers for Disease Control and Prevention (CDC), the National Cancer Institute (NCI), and the North American Association of Central Cancer Registries (NAACCR) collaborate annually to provide information on cancer rates and trends in the United States. This year's report updates statistics on the 15 most common cancers in the five major racial/ethnic populations in the United States for 1992–2002 and features population-based trends in cancer treatment.** ***Methods:*** **The NCI, the CDC, and the NAACCR provided information on cancer cases, and the CDC provided information on cancer deaths. Reported incidence and death rates were age-adjusted to the 2000 U.S. standard population, annual percent change in rates for fixed intervals was estimated by linear regression, and annual percent change in trends was estimated with joinpoint regression analysis. Population-based treatment data were derived from the Surveillance, Epidemiology, and End Results (SEER) Program registries, SEER-Medicare linked databases, and NCI Patterns of Care/Quality of Care studies.** ***Results:*** **Among men, the incidence rates for all cancer sites combined were stable from 1995 through 2002. Among women, the incidence rates increased by 0.3% annually from 1987 through 2002. Death rates in men and women combined decreased by 1.1% annually from 1993 through 2002 for all cancer sites combined and also for many of the 15 most common cancers. Among women, lung cancer death rates increased from 1995 through 2002, but lung cancer incidence rates stabilized from 1998 through 2002. Although results of cancer treatment studies suggest that much of contemporary cancer treatment for selected cancers is consistent with evidence-based guidelines, they also point to geographic, racial, economic, and age-related disparities in cancer treatment.** ***Conclusions:*** **Cancer death rates for all cancer sites combined and for many common cancers have declined at the same time as the dissemination of guideline-based treatment into the community has increased, although this progress is not shared equally across all racial and ethnic populations. Data from population-based cancer registries, supplemented by linkage with administrative databases, are an important resource for monitoring the quality of cancer treatment. Use of this cancer surveillance system, along with new developments in medical informatics and electronic medical records, may facilitate monitoring of the translation of basic science and clinical advances to cancer prevention, detection, and uniformly high quality of care in all areas and populations of the United States. [J Natl Cancer Inst 2005;97:1407–27]**

The American Cancer Society (ACS), the Centers for Disease Control and Prevention (CDC), the National Cancer Institute (NCI), and the North American Association of Central Cancer Registries (NAACCR) collaborate each year to produce a report to the nation on the current status of cancer in the United States. The initial report, in 1998, documented the first sustained decline in cancer death rates since national record keeping was instituted in the 1930s *(1)*. Subsequent reports have generally confirmed this finding and provided updated information *(2–7)*.

The 2004 report *(7)* focused on cancer survival trends and on the incidence and death rates for the 15 most common cancers in each of the five major racial/ethnic populations in the United States—white, black, Asian/Pacific Islander (API), American Indian/Alaska Native (AI/AN), and Hispanic/Latino. In this report, we update the cancer incidence and death rates and

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identify trends in these rates in the United States for men and for women, separately.

There has been a growing concern that not all cancer patients in the United States receive the full benefit of cancer treatments that have been shown to be effective and appropriate on the basis of the accumulated evidence from controlled clinical trials *(8)*. In response to this concern, there has been an increased effort in recent years to monitor trends in cancer treatment, to understand patterns of cancer treatment across different population groups, and to elucidate the factors that determine these patterns. For example, a 2000 Institute of Medicine report *(9)* on data systems to improve the quality of cancer care stated, "complete ascertainment of incident cancer cases by cancer registries is a prerequisite for national quality assessments, allowing case selection for studies whose results can be generalized to the total population, as well as assessments of quality for important subgroups, for example, individuals of low socioeconomic status, and individuals enrolled in certain types of health plans or delivery systems."

This report also includes a special section in which we review and update population-based studies of trends in cancer treatment and determinants of cancer treatment patterns of care, using cancer registry data to select cases and to identify demographic and clinical characteristics.

Subjects and Methods

Cancer Cases and Deaths

Information on newly diagnosed cancer cases in the United States was based on data collected by cancer registries participating in the NCI's Surveillance, Epidemiology, and End Results (SEER) Program and/or the CDC's National Program of Cancer Registries (NPCR) *(10–13)*. All cancer registries are members of the NAACCR *(14)*. For all cancers except bladder cancer, incidence data refer to invasive but not in situ cancers (data on the incidence of bladder cancer refers to both invasive and in situ cancers). For incident cases diagnosed in 2001 or later, all information concerning the primary cancer site and histology was coded according to the International Classification of Diseases for Oncology, third edition (ICD-O-3; *15*); cases diagnosed before 2001 were coded according to the ICD-O, second edition (ICD-O-2; *16*) and then converted to ICD-O-3 codes. For analysis, all cases were categorized according to SEER site groups *(17)*. To maximize comparability between ICD-O-2 and ICD-O-3, borderline tumors of the ovary, refractory anemias, and other myelodysplastic syndromes were excluded, and pilocytic astrocytomas (which were excluded from ICD-O-3 as malignant tumors) were included in analyses for this report.

Cancer deaths in the United States occurring from 1975 through 2002 that are reported to state vital statistics offices and consolidated into a database by CDC through the National Vital Statistics System *(18)* were coded according to the version of the ICD in use in the United States at the time they occurred *(19–21)*. Beginning with 1999 mortality data, ICD-10 was used to code the cause of death. Cancer was slightly more likely to be selected as the underlying cause of death under ICD-10 rules than under previous ICD rules *(22)*. Cancer sites were grouped by the SEER Program to allow for maximum comparability between versions of ICD codes *(17)*.

For the long-term (i.e., 1975 through 2002) trend analyses of incidence and death rates for all cancers combined and for the 15 most common cancers among all racial and ethnic populations combined, we used SEER incidence data from nine registries *(23)*, which cover approximately 10% of the U.S. population, and 100% of the U.S. population death data from the CDC. For the more recent (i.e., 1992 through 2002) trend analyses of incidence and death rates for the 15 most common cancers in each major racial and ethnic population (i.e., white, black, API, AI/AN, and Hispanic/Latino populations), we used incidence data from 13 SEER cancer registries (SEER13), which cover approximately 14% of the U.S. population, including 12% of whites, 12% of blacks, 36% of APIs, 21% of AI/ANs, and 22% of Hispanics/Latinos *(13)* and total U.S. death data from the CDC. We examined incidence data for 23 cancer sites or types and death data for 22 cancer sites or types to ensure that we would cover the 15 most common cancers in each racial and ethnic population. In this reports, we considered Kaposi sarcoma and mesothelioma cases separately from other cancer sites or types, in contrast to previous reports. Kaposi sarcoma and mesothelioma were reported as causes of death beginning in 1999; therefore, we did not report them separately for mortality. Although cancer registries collected information on cancer incidence and death among specific API and Hispanic/Latino populations, incidence and death rates for these populations could not be calculated because of the lack of intercensal county population estimates from the U.S. Bureau of the Census. Estimates of cancer incidence and death rates aggregated from data across different geographic regions can differ, reflecting regional and racial/ethnic variations *(17,24)*.

Cancer Treatment

Data regarding patterns and trends of cancer treatment in the United States were obtained from published and unpublished SEER and SEER-Medicare databases and from NCI Patterns of Care/Quality of Care (POC/QOC) studies that were based on samples of SEER cases. The NCI has been conducting POC/QOC studies since 1987 *(25)* and has linked SEER data to Medicare data since 1986 to create a database for health services research *(26–28)*. Information about surgery for early-stage breast cancer was derived from cases diagnosed from 1991 through 2002 and reported in SEER11 registries [i.e., Connecticut, Hawaii, Iowa, Utah, and New Mexico, and the metropolitan areas of San Francisco, Detroit, Atlanta, Seattle-Puget Sound, San Jose-Monterey, and Los Angeles County *(29)*]; SEER11 has population coverage similar to that for SEER13 but does not include Alaska Natives or residents of rural Georgia. Information about adjuvant therapy for early-stage breast cancer was from a population-based POC/QOC study of a sample of cases that were diagnosed in 1987, 1990, and 1995 *(30)* and was updated with data from cases diagnosed in 2000 *(30)*. Treatment data for stages II and III colorectal cancer were from a POC/QOC study for a sample of cases diagnosed in 1987, 1991, and 1995 *(31)* and from SEER-Medicare databases for cases diagnosed from 1997 through 1999 *(32)*. Analyses of treatment for non–small-cell lung cancer (NSCLC) were based on data from a POC/QOC study *(33)* and a SEER-Medicare database *(34)*. Information about the receipt of guideline therapy for ovarian cancer was derived from a POC/QOC study conducted on sample cases diagnosed in 1991 and 1996 *(35)*. The two studies of trends in treatment for early-stage prostate cancer patients diagnosed in 1986 through 1993 and 1991 through 1999 were based on SEER–Medicare data *(36,37)*.

Statistical Analysis

Cancer incidence and death rates, expressed per 100 000 persons, were age-adjusted by 19 age groups, typically in 5-year age categories (i.e., younger than 1 year, 1–4 years, 5–9 years, 10–14 years, …, 75–79 years, 80–84 years, and 85 years or older) to the 2000 U.S. standard population *(17)*. Weights were calculated using population projections from the U.S. Bureau of the Census *(38,39)* for the year 2000 and methodology developed from published guidelines *(40)*. Rates calculated using the new 19 age-group 2000 U.S. standard population weights *(41)* were virtually identical to those calculated using the 19 age-group U.S. 2000 standard million *(41)* weights developed for earlier reports. The CDC's National Center for Health Statistics publishes age-adjusted mortality rates, obtained using the established methodology, that are based on 11 age groups, typically in 10-year age categories (i.e., younger than 1 year, 1–4 years, 5–14 years, 15–24 years, …, 65–74 years, 75–84 years, and 85 years or older) and weights from the year 2000 population projections *(38,42)*. The number of age groups used for age adjustment may affect estimated rates slightly, whereas the effects of weights within an age group are negligible when an adequate number of significant digits is retained *(41)*. More detailed information on the change to the U.S. standard population and comparison to the U.S. standard million population can be found at http://seer.cancer.gov/stdpopulations/single_age.html. The process of age adjustment allows comparisons of rates among multiple groups, such as those defined by sex, race, and year of diagnosis, while eliminating the effect of differences in the age structures of the groups.

Estimates of rates, standard errors, and 95% confidence intervals were generated using SEER*Stat version 5.0.17 software *(23)*; standard error estimates [based on the gamma method *(43)*] and 95% confidence intervals results are available at http://jncicancerspectrum.oupjournals.org/jnci/content/vol97/issue19.

The long-term trends (i.e., from 1975 through 2002) in cancer incidence and mortality among all races/ethnicities combined were described by joinpoint regression analysis, which involves fitting a series of joined straight lines on a log scale to the age-adjusted rates *(44)*. Line segments are joined at points called joinpoints. Each line segment is described by an annual percent change, which is based on the slope of the line segment, and each joinpoint denotes a statistically significant change in trend. The overall statistical significance was set to $P<.05$, and a maximum of three joinpoints and four line segments was allowed for each model. We present incidence trends that are based on observed data and on data that were adjusted for delays in reporting *(45)*. This delay adjustment facilitates the interpretation of incidence trends, especially because recent diagnosis years are most affected by reporting delays. We used statistical models to adjust the current cancer counts for anticipated future improvements to the data on the basis of long-term observed reporting patterns in SEER registries *(45)*.

Descriptions of long-term cancer incidence trends are based on the delay-adjusted rates, except where specifically noted. For each racial and ethnic population, the annual percent changes for a more recent fixed time period (i.e., 1992 through 2002) were estimated by fitting a linear regression line to the natural logarithms of the rates, using calendar year as the independent variable *(3)*. The annual percent change for the fixed time period is the best measure for comparison among groups because the beginning and ending years are the same. In describing trends, we use the terms "increase(d)" or "decrease(d)" only when the slope (coefficient) of the trend is statistically significant different from zero (two-sided $P<.05$); otherwise, we use the terms "stable" or "level." Absolute changes in cancer incidence and death rates were calculated as the difference between the 2002 and the 1992 age-adjusted rates.

More detailed information and methodology related to this report are available at the NCI Web sites www.seer.cancer.gov/report_to_nation/1975_2002/ and www.cancer.gov. Additional data on cancer incidence and mortality are available from the following sites: www.cancer.org (ACS); www.cdc.gov/cancer/npcr/index.htm and www.cdc.gov/nchs/about/major/dvs/mortdata.htm (CDC); and www.naaccr.org/CINAP/index.htm (NAACCR).

Results

Update on Long-Term Incidence Trends for All Cancer Sites Combined and for the 15 Most Common Cancer Sites for All Races, 1975–2002

For all populations combined (Table 1), age-adjusted cancer incidence rates for all sites combined were stable since 1992. Among men, incidence rates for all cancer sites combined were stable from 1995 through 2002. Among women, incidence rates increased by 0.3% per year from 1987 through 2002.

Among men, cancer incidence rates increased during the most recent segment (from the last joinpoint until 2002) for melanoma of the skin (melanoma) and cancers of the prostate, kidney and renal pelvis (kidney), and esophagus, but decreased for cancers of the lung and bronchus (lung), colon and rectum, oral cavity and pharynx (oral cavity), stomach, and larynx. Incidence rates for the remaining 15 cancer sites were stable. The long-term trends in incidence rates for prostate cancer fluctuated greatly, as we previously reported *(3–7)*.

Among women, cancer incidence rates increased during the most recent segment (from the last joinpoint until 2002) for leukemia, non-Hodgkin lymphoma, melanoma, and cancers of the breast, thyroid, urinary bladder (bladder), and kidney. Female breast cancer incidence rates increased by 0.4% per year from 1987 through 2002, a slower rate of increase than in the previous time period (i.e., increase of 3.7% per year from 1980 through 1987). The cancer incidence rates decreased for cancers of the colon and rectum, ovary, cervix uteri, oral cavity, and stomach. Incidence rates for the remaining cancer sites were stable. It is important to note that the stabilization of lung cancer incidence rates among women since 1998 occurred after they had increased for many decades, i.e., by 5.5% per year from 1975 through 1982, by 3.5% per year from 1982 through 1990, and by 1.0% per year from 1990 through 1998.

Update on the Long-Term Mortality Trends for All Cancer Sites Combined and for the 15 Most Common Cancer Sites for All Races, 1975–2002

Overall cancer death rates for all racial and ethnic populations combined decreased by 1.1% per year from 1993 through 2002; the decline was more pronounced among men (1.5% per year from 1993 through 2002) than among women (0.8% per year from 1992 through 2002) (Table 2). Mortality trends for the 15 most common cancers differed slightly between men and women. Death rates decreased for 12 of the 15 most common cancers in men (i.e., lung, prostate, colon and rectum, pancreas, non-Hodgkin lymphoma, leukemia, bladder, stomach, and brain and other nervous system [brain], myeloma, oral cavity, and melanoma) and for nine of the

Table 1. SEER cancer incidence rate trends with joinpoint analyses for 1975 through 2002 for the 15 most common cancers, by sex, for all races*

	Joinpoint analyses (1975–2002)†							
	Trend 1		Trend 2		Trend 3		Trend 4	
Cancer site or type	Years	APC‡	Years	APC‡	Years	APC‡	Years	APC‡
All sites§								
Both sexes	1975–1983	0.9‖	1983–1992	1.8‖	1992–1995	−1.6	1995–2002	0.0
(Delay-adjusted)	1975–1983	0.9‖	1983–1992	1.8‖	1992–1995	−1.7	1995–2002	0.3
Male	1975–1989	1.3‖	1989–1992	5.1‖	1992–1995	−4.6‖	1995–2002	−0.2
(Delay-adjusted)	1975–1989	1.3‖	1989–1992	5.2	1992–1995	−4.7‖	1995–2002	0.2
Female	1975–1979	−0.2	1979–1987	1.5‖	1987–1999	0.3‖	1999–2002	−0.8
(Delay-adjusted)	1975–1979	−0.2	1979–1987	1.5‖	1987–2002	0.3‖		
15 most common cancers for males								
Prostate	1975–1988	2.6‖	1988–1992	16.4‖	1992–1995	−11.2‖	1995–2002	1.3‖
(Delay-adjusted)	1975–1988	2.6‖	1988–1992	16.5‖	1992–1995	−11.2‖	1995–2002	1.7‖
Lung and bronchus	1975–1981	1.7‖	1981–1991	−0.3	1991–2002	−2.0‖		
(Delay-adjusted)	1975–1982	1.5‖	1982–1991	−0.4	1991–2002	−1.8‖		
Colon and rectum	1975–1986	1.1‖	1986–1995	−2.1‖	1995–1998	1.0	1998–2002	−2.9‖
(Delay-adjusted)	1975–1986	1.1‖	1986–1995	−2.1‖	1995–1998	1.0	1998–2002	−2.5‖
Urinary bladder	1975–1987	1.0‖	1987–1996	−0.5	1996–2000	1.5	2000–2002	−3.5
(Delay-adjusted)	1975–1987	1.0‖	1987–1996	−0.5	1996–2000	1.6	2000–2002	−2.6
Non-Hodgkin lymphoma	1975–1991	4.3‖	1991–2002	−0.1				
(Delay-adjusted)	1975–1991	4.3‖	1991–2002	0.2				
Melanoma of the skin¶	1975–1985	5.7‖	1985–2000	3.6‖	2000–2002	−1.2		
(Delay-adjusted)¶	1975–1985	5.8‖	1985–2002	3.8‖				
Leukemia	1975–2002	−0.3‖						
(Delay-adjusted)	1975–2002	0.1						
Oral cavity and pharynx	1975–1983	−0.1	1983–2002	−1.5‖				
(Delay-adjusted)	1975–2002	−1.2‖						
Kidney and renal pelvis	1975–2002	1.7‖						
(Delay-adjusted)	1975–2002	1.8‖						
Stomach	1975–1988	−1.2‖	1988–2002	−2.1‖				
(Delay-adjusted)	1975–1988	−1.2‖	1988–2002	−2.0‖				
Pancreas	1975–1981	−1.8‖	1981–1985	1.2	1985–1989	−2.4	1989–2002	−0.1
(Delay-adjusted)	1975–1981	−1.8‖	1981–1985	1.1	1985–1990	−2.1	1990–2002	0.1
Liver and intrahepatic bile duct	1975–1984	1.7	1984–1999	4.5‖	1999–2002	−2.1		
(Delay-adjusted)	1975–1984	1.7	1984–1999	4.5‖	1999–2002	−0.7		
Brain and other nervous system	1975–1989	1.2‖	1989–2002	−0.5				
(Delay-adjusted)	1975–1989	1.2‖	1989–2002	−0.3				
Esophagus	1975–2002	0.7‖						
(Delay-adjusted)	1975–2002	0.8‖						
Larynx	1975–1988	−0.2	1988–2002	−2.8‖				
(Delay-adjusted)	1975–1988	−0.3	1988–2002	−2.8‖				
15 most common cancers for females								
Breast	1975–1980	−0.5	1980–1987	3.8‖	1987–2002	0.3‖		
(Delay-adjusted)	1975–1980	−0.4	1980–1987	3.7‖	1987–2002	0.4‖		
Lung and bronchus	1975–1982	5.5‖	1982–1990	3.5‖	1990–1998	1.0‖	1998–2002	−1.1
(Delay-adjusted)	1975–1982	5.5‖	1982–1990	3.5‖	1990–1998	1.0‖	1998–2002	−0.5
Colon and rectum	1975–1985	0.3‖	1985–1995	−1.8‖	1995–1998	1.5	1998–2002	−1.9‖
(Delay-adjusted)	1975–1985	0.3‖	1985–1995	−1.8‖	1995–1998	1.5	1998–2002	−1.5‖
Corpus and uterus, NOS	1975–1979	−6.0‖	1979–1988	−1.7‖	1988–1998	0.6‖	1998–2002	−1.1
(Delay-adjusted)	1975–1979	−6.0	1979–1988	−1.7‖	1988–1997	0.7‖	1997–2002	−0.6
Non-Hodgkin lymphoma	1975–1990	2.9‖	1990–2002	0.9‖				
(Delay-adjusted)	1975–1990	2.9‖	1990–2002	1.2‖				
Ovary#	1975–1987	0.1	1987–2002	−0.9‖				
(Delay-adjusted)	1975–1985	0.2	1985–2002	−0.7‖				
Melanoma of the skin¶	1975–1980	6.1‖	1980–2002	2.6‖				
(Delay-adjusted)¶	1975–1981	6.1‖	1981–1993	2.2‖	1993–2002	4.1‖		
Pancreas	1975–1984	1.3‖	1984–2002	−0.3‖				
(Delay-adjusted)	1975–1984	1.2‖	1984–2002	−0.2				
Thyroid	1975–1977	6.4	1977–1980	−4.9	1980–1993	2.1‖	1993–2002	5.0‖
(Delay-adjusted)	1975–1981	−1.2	1981–1993	2.0‖	1993–2002	5.3‖		
Cervix uteri	1975–1981	−4.6‖	1981–1997	−1.1‖	1997–2002	−4.8‖		
(Delay-adjusted)	1975–1981	−4.6‖	1981–1997	−1.1‖	1997–2002	−4.5‖		
Leukemia	1975–2002	−0.1						
(Delay-adjusted)	1975–2002	0.2‖						
Urinary bladder	1975–2002	0.2‖						
(Delay-adjusted)	1975–2002	0.2‖						

(Table continues)

Table 1 (continued).

Cancer site or type	Joinpoint analyses (1975–2002)†							
	Trend 1		Trend 2		Trend 3		Trend 4	
	Years	APC‡	Years	APC‡	Years	APC‡	Years	APC‡
Kidney and renal pelvis	1975–1991	2.7‖	1991–2002	1.3‖				
(Delay-adjusted)	1975–1990	2.8‖	1990–2002	1.6‖				
Oral cavity and pharynx	1975–1980	2.6‖	1980–2002	−1.0‖				
(Delay-adjusted)	1975–1980	2.5	1980–2002	−0.9‖				
Stomach	1975–2002	−1.7‖						
(Delay-adjusted)	1975–2002	−1.7‖						

*Sources of data are the Surveillance, Epidemiology, and End Results (SEER) Program registries of San Francisco, Detroit, Atlanta, and Seattle-Puget Sound (i.e., SEER9). Joinpoint analysis was performed with the use of the Joinpoint (JP) Regression Program, version 3.0, April 2005, National Cancer Institute. The 15 most common cancers were selected on the basis of the sex-specific age-adjusted incidence rates for 1992–2002 for all races combined. A spreadsheet that contains the standard errors and 95% confidence intervals for the APCs is available at http://jncicancerspectrum.oupjournals.org/jnci/content/vol97/issue19. APC = annual percent change; NOS = not otherwise specified.

†Joinpoint analyses with up to three joinpoints are based on rates per 100 000 persons and are age-adjusted to the 2000 U.S. standard population (using 19 age groups, with data provided from Census Current Population Reports series, P25-1130 *(39)*.

‡APC is based on rates that were age-adjusted to *y* and SEERProgram registries that include Connecticut, Hawaii, Iowa, Utah, and New Mexico, and the metropolitan are the 2000 U.S. standard population (using 19 age groups, with data provided from Census Current Population Reports series, P25-1130 (*39*) using joinpoint regression analysis.

§Excludes myelodysplastic syndromes and borderline tumors.

‖APC is statistically significantly different from zero (two-sided $P<.05$).

¶Age-adjusted rates for melanoma of the skin are calculated using white patients only.

#Excludes borderline tumors.

15 most common cancers in women (i.e., breast, colon and rectum, non-Hodgkin lymphoma, leukemia, brain, stomach, myeloma, cervix uteri, and bladder). For melanoma, death rates decreased in men (by 1.6% per year from 1998 through 2002); for multiple myeloma, death rates decreased in both men (by 0.9% per year from 1994 through 2002) and women (by 0.5% per year from 1993 through 2002). Among men, death rates increased for esophageal cancer (by 0.5% per year from 1994 through 2002) and for liver cancer (by 1.6% per year from 1995 through 2002). Among women, death rates increased for lung cancer (by 0.3% per year from 1995 through 2002). Death rates were stable for kidney cancer in men and women and for five of the 15 most common cancers in women (i.e., kidney, pancreas, ovary, corpus uteri, and liver and intrahepatic bile duct [liver]). Further joinpoint analyses of age-specific lung cancer death rates among women by 10-year age intervals showed that lung cancer death rates increased for women aged 40–49 years and 70 years or older (data not shown).

Cancer Incidence and Death Rates for the 15 Most Common Cancer Sites by Race and Ethnicity, 1992–2002

We ranked the 15 most frequently occurring cancers diagnosed from 1992 through 2002 in terms of age-adjusted incidence rates (Table 3) and age-adjusted death rates (Table 4) for all races combined and for each major racial and ethnic population by sex. The highest cancer incidence and death rates for each racial and ethnic population continued to be for cancers of the prostate, lung, and colon and rectum among men and for cancers of the breast, lung, and colon and rectum among women.

Examination of age-adjusted incidence trends by race and ethnicity from 1992 through 2002 revealed that the incidence rates for lung and prostate cancers declined among men in all racial/ethnic populations; colorectal cancer incidence rates decreased only for white men (Table 3). Although our analysis of trends for this period permits valid comparisons of trends by race, sex, and cancer site, the declines in prostate cancer incidence rates observed from 1992 through 2002 (Table 3) masked a change in the direction of the incidence trend that began in 1995, as identified by the joinpoint analysis (Table 1) for all race/ethnic groups combined. Prostate cancer incidence rates increased from 1995 through 2002. Among women, breast cancer incidence rates increased among API women, decreased among AI/AN women, and were stable for other women; lung cancer rates decreased in AI/AN and Hispanic/Latina women and were stable for the other populations; colorectal cancer incidence rates decreased only for white women.

Trends in incidence rates for other cancers also varied among different racial and ethnic populations and by sex, although most trends among AI/ANs could not be evaluated because of the small number of cases (Table 3). Incidence rates for liver cancer increased among men in all groups except APIs and AI/ANs and among white and Hispanic/Latina women. We observed declines in the incidence rates for cancers of the stomach and larynx among men in all populations except AI/ANs. Incidence rates for cancers of the oral cavity also decreased among men in all populations except APIs, and incidence rates for Kaposi sarcoma decreased among white, black, and Hispanic/Latino men. Cervical cancer rates decreased among women in all racial and ethnic populations. Incidence rates for thyroid and kidney cancer increased among women in all racial and ethnic populations except AI/ANs.

An analysis of recent (i.e., from 1992 through 2002) mortality trends revealed declines in death rates for lung, prostate, and colon and rectal cancers among men in most racial and ethnic populations; the exceptions were death from lung cancer among AI/AN men and from colon and rectal cancer among AI/AN and Hispanic/Latino men (Table 4). Death rates for colorectal cancer declined among white, black, and API women, and death rates for breast cancer declined among white, black, and Hispanic/Latina women. Although the lung cancer death rates continued to increase among white women and black women, these annual increases are substantially lower than increases reported for all women before 1992 (Table 1) and are consistent with long-term trends of slowing rates of increase over time.

Table 2. U.S. death rate trends with joinpoint analyses for 1975 through 2002 for the 15 most common cancers for all races*

	Joinpoint analyses (1975–2002)†							
	Trend 1		Trend 2		Trend 3		Trend 4	
Cancer site or type	Years	APC	Years	APC‡	Years	APC‡	Years	APC‡
All sites								
Both sexes	1975–1990	0.5§	1990–1993	−0.3	1993–2002	−1.1§		
Male	1975–1979	1.0§	1979–1990	0.3§	1990–1993	−0.4	1993–2002	−1.5§
Female	1975–1992	0.5§	1992–2002	−0.8§				
15 most common cancers for males								
Lung and bronchus	1975–1978	2.4§	1978–1984	1.2§	1984–1991	0.3§	1991–2002	−1.9§
Prostate	1975–1987	0.9§	1987–1991	3.1§	1991–1994	−0.6	1994–2002	−4.0§
Colon and rectum	1975–1978	0.8	1978–1984	−0.4	1984–1990	−1.3§	1990–2002	−2.0§
Pancreas	1975–1986	−0.8§	1986–2002	−0.3§				
Non-Hodgkin lymphoma	1975–1981	1.8§	1981–1990	3.0§	1990–1997	1.6§	1997–2002	−2.8§
Leukemia	1975–1995	−0.2§	1995–2002	−0.7§				
Urinary bladder	1975–1983	−1.4§	1983–1987	−2.7§	1987–1993	0.1	1993–2002	−0.6§
Esophagus	1975–1985	0.7§	1985–1994	1.2§	1994–2002	0.5§		
Stomach	1975–1987	−2.3§	1987–1991	−0.9	1991–2002	−3.5§		
Liver and intrahepatic bile duct	1975–1986	1.7§	1986–1995	3.9§	1995–2002	1.6§		
Kidney and renal pelvis	1975–1991	1.1§	1991–2002	−0.1				
Brain and other nervous system	1975–1977	4.4	1977–1982	−0.4	1982–1990	1.5§	1990–2002	−0.7§
Myeloma	1975–1994	1.5§	1994–2002	−0.9§				
Oral cavity and pharynx	1975–1991	−1.8§	1991–2002	−2.6§				
Melanoma of the skin	1975–1987	2.4§	1987–1998	0.8§	1998–2002	−1.6§		
15 most common cancers for females								
Lung and bronchus	1975–1982	6.0§	1982–1990	4.2§	1990–1995	1.7§	1995–2002	0.3§
Breast	1975–1990	0.4§	1990–2002	−2.3§				
Colon and rectum	1975–1984	−1.0§	1984–2002	−1.8§				
Pancreas	1975–1984	0.8§	1984–2002	0.1				
Ovary	1975–1982	−1.2§	1982–1992	0.3§	1992–1998	−1.2§	1998–2002	0.8
Non-Hodgkin lymphoma	1975–1994	2.2§	1994–1997	1.0	1997–2002	−3.2§		
Leukemia	1975–1980	0.8	1980–2002	−0.4§				
Corpus and uterus, NOS	1975–1989	−1.6§	1989–1997	−0.7§	1997–2002	0.5		
Brain and other nervous system	1975–1992	0.9§	1992–2002	−1.0§				
Stomach	1975–1987	−2.8§	1987–1990	−0.5	1990–2002	−2.6§		
Myeloma	1975–1993	1.5§	1993–2002	−0.5§				
Cervix uteri	1975–1982	−4.4§	1982–1996	−1.6§	1996–2002	−3.8§		
Liver and intrahepatic bile duct	1975–1978	−1.5	1978–1988	1.4§	1988–1995	3.9§	1995–2002	0.4
Kidney and renal pelvis	1975–1992	1.3§	1992–2002	−0.5				
Urinary bladder	1975–1986	−1.7§	1986–2002	−0.3§				

*Sources of data are the Surveillance, Epidemiology, and End Results (SEER) Program registries that include Connecticut, Hawaii, Iowa, Utah, and New Mexico and the metropolitan areas of San Francisco, Detroit, Atlanta, and Seattle-Puget Sound (i.e., SEER9). Joinpoint analysis was performed with the use of the Joinpoint (JP) Regression Program, version 3.0, April 2005, National Cancer Institute. The 15 most common cancers were selected on the basis of the sex-specific age-adjusted incidence rates for 1992–2002 for all races combined. A spreadsheet that contains the standard errors and 95% confidence intervals for the APCs is available at http://jncicancerspectrum.oupjournals.org/jnci/content/vol97/issue19. APC = annual percent change; NOS = not otherwise specified.

†Joinpoint analyses with up to three joinpoints are based on rates per 100 000 persons and are age-adjusted to the 2000 U.S. standard population (using 19 age groups, with data provided from Census Current Population Reports series, P25-1130 *(39)*.

‡APC is based on rates that were age-adjusted to the 2000 U.S. standard population (using 19 age groups, with data provided from Census Current Population Reports series, P25-1130 *(39)* using joinpoint regression analysis.

§APC is statistically significantly different from zero (two-sided $P<.05$).

Mortality trends for cancers other than the three most common cancers also varied by racial and ethnic group and by sex (Table 4). From 1992 through 2002, the death rates for liver cancer increased among white, black, and Hispanic/Latino men and among white and Hispanic/Latina women. Stomach cancer death rates declined for men and women of all racial and ethnic populations except for AI/AN men and women. Similarly, declines in death rates for oral cavity cancers were observed among men and women in most populations, except for AI/AN men and women, API women, and Hispanic/Latina women. Finally, death rates for cancers of the gallbladder declined among white, API, and Hispanic/Latina women, and cervical cancer death rates declined among women in all populations.

Special Section: Monitoring Cancer Treatment Trends and Determinants Using Data from Population-Based Cancer Registries

One strategy for reducing the number of cancer deaths and improving survival among those diagnosed with cancer is to ensure that evidence-based cancer treatment services are available and

accessible. Here we discuss the results of several studies that have examined trends in the delivery and determinants of cancer treatment and present results of some new analyses. Although we focus on the treatment of breast cancer, we also present abbreviated findings for the treatment of colorectal cancer, NSCLC, and cancers of the ovary and prostate. We also briefly summarize findings on the relationship between provider procedure volume and outcomes, on care during the last year of life, and on cancer treatment cost.

Evaluations of Cancer Care Delivery

Several studies *(30,31)* have examined trends in the dissemination of appropriate cancer treatment as defined by statements issued by the National Institutes of Health (NIH) Consensus Development Program *(46)* or by specific NCI clinical alerts that reflect emerging evidence of treatment efficacy from controlled clinical trials. In other studies *(47,48)*, treatment patterns have been compared with clinical guidelines issued by professional organizations concerned with specialty cancer care. In all of these studies, patterns of care were evaluated relative to the most recently published guidelines before the year of diagnosis under examination.

Trends in Early-Stage Breast Cancer Treatment. Data from SEER registries and NCI POC/QOC studies have been used to study two treatment regimens for early-stage breast cancer: 1) breast-conserving surgery and radiation, and 2) adjuvant chemotherapy and hormonal therapy.

Breast-conserving surgery and radiation. Clinical trials have demonstrated that women with early-stage breast cancer who receive breast-conserving surgery followed by radiation have survival outcomes similar to those of women who receive a mastectomy *(49)*. A 1990 NIH Consensus Development Panel concluded that "breast conservation treatment (breast-conserving surgery followed by radiation therapy) is an appropriate method of primary therapy for the majority of women with stage I and II breast cancer and is preferable because it provides survival equivalent to total mastectomy and axillary dissection while preserving the breast" *(49)*. Breast-conserving surgery followed by radiation therapy is associated with a lower rate of local recurrence than breast-conserving surgery alone *(49,50)*.

Data from SEER11 on trends in the treatment of early-stage breast cancer (Fig. 1) show that the proportion of women diagnosed with stage I and II breast cancer who received breast-conserving surgery and radiation treatment increased substantially during the 1990s and that the proportion of women who received breast-conserving surgery only also increased modestly. The proportion of women 65 years or older at diagnosis who received breast-conserving surgery and radiation treatment was lower than the proportion of women younger than 65 years at diagnosis who received this treatment (Fig. 1).

Two studies examined factors associated with breast-conserving surgery and radiation among women aged 65 or older at diagnosis. Ballard-Barbash et al. *(51)*, using SEER-Medicare data, found that, from 1985 through 1989, 55% of women enrolled in Medicare who were diagnosed with early-stage breast cancer (stage I and II) and received breast-conserving surgery also received radiation treatment. Women with preexisting comorbid conditions were less likely to receive radiation therapy than were women with no comorbid conditions (adjusted odd ratios for women with no comorbid conditions, with one comorbid condition, and with two or more comorbid conditions were 1.00, 0.52, and 0.33, respectively). There was also a strong inverse relationship between age at diagnosis and receipt of radiation therapy among women aged 65 years or older, even after adjusting for comorbidity (adjusted odds ratios for women aged 65–69 years, 70–74 years, 75–79 years, and 80 years or older were 1.00, 0.70, 0.44, and 0.12, respectively). Riley et al. *(52)* found that patients with early-stage breast cancer (stage I and II) who were enrolled in health maintenance organizations (HMOs) were, on average, as likely to undergo breast-conserving surgery as women who were enrolled in fee-for-service (FFS) health plans in the same geographic area and that patients in HMOs were more likely than women in FFS health plans to receive radiation therapy. These investigators also found that results varied across the nine SEER areas studied (e.g., in three of the areas, FFS patients were more likely to receive radiation treatment than were HMO patients).

Adjuvant chemotherapy and hormonal therapy for early-stage breast cancer. In recent decades, the treatments recommended for women with early-stage breast cancer by NIH Consensus Development Conference statements and clinical alerts *(49,53)* have changed (Fig. 2). In 1985, recommendations for lymph node–positive breast cancer patients were established. Multiagent chemotherapy was recommended for premenopausal women and for postmenopausal women with estrogen receptor–negative tumors. For women with estrogen receptor–positive tumors, tamoxifen was recommended. In May 1988, on the basis of new clinical trial results, the NCI issued a clinical alert advising the use of multiagent chemotherapy for lymph node–negative patients with tumors larger than 3 cm and for lymph node–negative patients with estrogen receptor–negative tumors of 3 cm or smaller *(53)*.

Harlan et al. *(30)* conducted an NCI POC/QOC study to describe therapies that were being used in community practice to treat women who resided in SEER areas and were newly diagnosed with breast cancer. They used comprehensive medical record reviews and physician contact to collect information about treatment. Data from this study of women diagnosed with early-stage breast cancer in 1987, 1990, and 1995 *(30)*, which we have updated using unpublished data for a sample of cases diagnosed in 2000 (Table 5), indicate that, by 1987, a substantial proportion of node–positive women with stages I–IIIA breast cancer were being treated with adjuvant therapy. Between 1987 and 2000, the use of concurrent chemotherapy and hormone (i.e., tamoxifen) therapy increased for node–positive women being treated for early-stage breast cancer, although its use remained relatively low among women aged 65 years or older, who were more likely to receive tamoxifen alone.

To translate these observed patterns of treatment into estimates of the proportion of women who received care according to guideline recommendations, Harlan et al. *(30)* also took into account the year of diagnosis (and the corresponding guidelines available during that year) and the estrogen receptor status of each patient. On the basis of this analysis, the authors *(30)* estimated that 70% of the patients with node–positive early-stage breast cancer treated between 1987 and 1989 received therapy as specified by guidelines, 75% of those treated in 1990 received guideline therapy, and 73% of those treated in 1995 received guideline therapy, after adjusting for age, race/ethnicity, registry, estrogen receptor status, tumor grade, tumor size, and the number of positive nodes.

The proportion of women with early-stage node-negative disease treated with adjuvant therapy increased from 1987 through 1995 but remained lower than the proportion of women with

Table 3. SEER incidence rates and trends for the 15 most common cancers by sex and race/ethnicity for 1992 through 2002*

Sex/cancer site or type	All races				Whites			
	Rank	Rate‡	APC§	AC‖	Rank	Rate‡	APC§	AC‖
Male								
All sites¶		570.9	−1.3#	−111.5		572.7	−1.3#	−114.3
Prostate	1	180.1	2.0#	−62.5	1	175.5	−2.1#	−67.9
Lung and bronchus	2	82.7	−2.2#	−19.9	2	81.5	−2.1#	−18.5
Colon and rectum	3	64.0	−1.2#	−10.4	3	63.8	−1.3#	−12.0
Urinary bladder	4	36.1	−0.2	−2.2	4	39.7	−0.1	−2.5
Non-Hodgkin lymphoma	5	23.7	−0.5	−0.5	5	24.9	−0.4	−0.6
Melanoma of the skin	6	20.4	2.5#	3.8	6	24.0	2.9#	5.3
Leukemia	7	16.4	−1.1#	−2.6	7	17.4	−1.1#	−2.6
Oral cavity and pharynx	8	16.4	−1.8#	−2.7	8	16.2	−1.5#	−2.3
Kidney and renal pelvis	9	15.5	1.4#	1.9	9	15.9	1.6#	2.0
Stomach	10	13.1	−2.1#	−2.5	11	11.3	−2.1#	−2.1
Pancreas	11	12.7	−0.4#	−0.6	10	12.5	0.1	−0.1
Liver and intrahepatic bile duct	12	8.6	3.0#	2.4	15	6.8	2.9#	1.8
Brain and other nervous system	13	7.7	−0.7	−0.9	12	8.5	−0.4	−0.9
Esophagus	14	7.6	0.3	−0.3	13	7.4	1.5#	0.5
Larynx	15	7.2	−3.3#	−2.7	14	7.1	−3.3#	−2.6
Myeloma	16	7.1	−0.5	−0.3	16	6.8	−0.3	−0.3
Kaposi sarcoma	18	4.4	−20.4#	−8.5	18	4.5	−22.4#	−9.4
Thyroid	19	3.7	3.1#	1.1	19	3.9	3.4#	1.3
Gallbladder	30	0.9	−1.5	−0.1	32	0.8	−0.9	0.0
Female								
All sites¶		412.1	0.1	−5.0		425.7	0.2	−1.9
Breast	1	132.4	0.4	0.0	1	138.3	0.5	1.3
Lung and bronchus	2	49.2	−0.2	−1.1	2	51.3	−0.1	−0.6
Colon and rectum	3	46.4	−0.6#	−3.9	3	45.9	−0.7#	−4.3
Corpus and uterus, NOS	4	24.4	−0.2	−0.8	4	25.9	−0.3	−1.8
Non-Hodgkin lymphoma	5	15.5	0.8#	1.2	5	16.3	0.8#	1.1
Ovary††	6	14.2	−0.9#	−1.6	7	15.1	−0.8#	−1.8
Melanoma of the skin	7	13.2	2.3#	2.3	6	15.9	3.0#	3.5
Pancreas	8	9.9	−0.3	0.0	11	9.6	−0.3	−0.1
Thyroid	9	9.8	4.8#	4.6	8	10.2	5.2#	5.3
Cervix uteri	10	9.7	−2.8#	−2.8	12	9.3	−2.2#	−2.4
Leukemia	11	9.6	−0.8#	−0.8	9	10.1	−0.5	−0.6
Urinary bladder	12	9.2	−0.4#	−0.4	10	9.9	−0.2	−0.2
Kidney and renal pelvis	13	7.6	1.4#	0.9	13	7.9	1.5#	0.8
Oral cavity and pharynx	14	6.7	−1.1#	−0.4	14	6.7	−1.2#	−0.4
Stomach	15	6.2	−0.7	−0.6	16	5.1	−1.0	−0.7
Brain and other nervous system	16	5.4	−0.5	−0.3	15	6.0	−0.1	−0.2
Myeloma	17	4.6	−0.8	−0.6	17	4.3	−0.8	−0.7
Liver and intrahepatic bile duct	18	3.3	3.3#	1.0	18	2.7	3.7#	0.9
Gallbladder	23	1.6	−1.5#	−0.4	23	1.6	−1.4	−0.3

(Table continues)

early-stage node-positive tumors treated with adjuvant therapy *(30)*. The 1990 NIH Consensus Development Statement on the treatment of early-stage breast cancer *(49)* indicated that patient preference should determine the choice of treatment for node-negative breast cancer, given that cure rates after surgery alone are relatively favorable and that chemotherapy results in only a modest improvement in these rates. After controlling for age, race/ethnicity, registry, estrogen receptor status, tumor grade, and tumor size, Harlan et al. *(30)* estimated that the percentage of women with early-stage node-negative breast cancer who received adjuvant therapy increased from 34% in 1987–1989 to 51% in 1990 and to 53% in 1995, following the 1988 publication of a clinical alert *(53)* that recommended adjuvant therapy for lymph node–negative tumors. There were relatively few changes in general treatment patterns between 1995 and 2000, except for a continued increase in the percentage of women younger than 51 years who were treated concurrently with chemotherapy and tamoxifen and a continued decrease in use of chemotherapy for tumors smaller than 1 cm.

Trends in Colorectal Cancer Treatment. On the basis of the accumulated evidence from clinical trials, a 1990 NIH Consensus Development Conference recommended treatment with adjuvant chemotherapy for patients with stage III colon cancer *(54)*. The evidence for the effectiveness of adjuvant chemotherapy in treating stage II colon cancer was less definitive. A subsequent meta-analysis of data from multiple trials for 1016 stage II colon cancer patients indicated that patients who were treated with adjuvant 5-fluorouracil plus leucovorin did not have statistically significantly better 5-year disease-free or overall survival than untreated control patients *(55)*.

The 1990 NIH Consensus Conference *(54)* also recommended combined adjuvant chemotherapy and high-dose external-beam radiotherapy to treat patients with stage II or III rectal cancer. The Consensus Conference noted that, although radiation therapy did not appear to affect disease-specific or overall survival, it substantially decreased local recurrence—an outcome associated with substantial morbidity in rectal cancer—and should therefore be considered an indicator of high-quality care.

Table 6 presents treatment patterns for colon and rectal cancers that were documented in an NCI POC/QOC study *(31)* of data from patients diagnosed in 1987, 1991, and 1995. By analyzing these data, Potosky et al. *(31)* found that the percentage of

Table 3 (continued).

Blacks				API				AI/AN				Hispanics/Latinos†			
Rank	Rate‡	APC§	AC‖	Rank	Rate‡	APC§	AC‖	Rank	Rate‡	APC§	AC‖	Rank	Rate‡	APC§	AC‖
	715.6	−1.7#	−127.1		394.4	−1.2#	−55.6		285.5	−3.8#	−101.3		429.6	−0.9#	−44.5
1	283.8	−1.9#	−55.0	1	104.6	−1.7#	−27.5	1	63.4	−6.8#	−44.9	1	143.1	−0.7	−13.3
2	122.8	−2.5#	−35.7	2	61.2	−1.4#	−14.0	2	49.8	−5.4#	−20.3	3	47.2	−2.0#	−7.2
3	72.9	−0.5	−4.6	3	56.9	−0.4	−0.6	3	40.8	−2.7	−7.3	2	48.1	0.0	−5.0
5	20.2	−0.2	1.5	6	16.8	1.1	2.8	9	8.3	**	**	5	19.0	−0.2	0.0
7	18.8	−1.2	−1.2	7	16.7	0.2	0.0	7	9.8	2.2	3.8	4	19.3	−0.9	−2.6
23	1.3	**	**	20	1.7	2.9	1.4	20	2.2	**	**	17	4.1	3.2#	1.6
11	12.9	−1.6	−3.6	10	9.8	−0.3	−0.2	12	5.5	**	**	9	11.8	−0.6	0.1
4	20.7	−3.1#	−6.0	8	12.6	−1.5	−0.9	6	11.3	−9.2#	−11.8	11	10.1	−2.8#	−2.3
8	18.5	2.2#	4.3	11	8.7	0.1	−0.1	4	15.6	−4.0#	−4.2	7	14.7	2.0#	2.5
6	19.5	−2.8#	−5.1	4	23.1	−3.3#	−7.7	5	14.6	**	4.8	6	18.3	−2.5#	−3.1
9	17.5	−2.5#	−5.4	9	10.7	−2.8#	−1.3	10	7.8	**	**	10	10.8	−0.9	−1.0
14	10.8	4.5#	4.3	5	20.9	1.0	2.0	8	9.0	**	**	8	13.4	2.2#	3.7
16	4.7	0.0	0.3	14	4.1	−1.6	−1.0	14	3.3	**	**	14	5.7	0.1	−0.1
13	12.4	−5.7#	−7.4	12	5.1	−2.0	−0.5	11	6.1	**	**	13	5.9	−1.2	−1.2
12	12.7	−3.2#	−5.8	16	3.5	−2.5#	−0.8	18	2.3	**	**	15	5.6	−1.6#	−1.2
10	13.5	−0.7	0.8	13	4.2	−1.4	−0.1	13	4.1	**	**	12	6.5	−1.1	0.5
15	6.4	−12.7#	−7.5	24	1.2	**	−1.5	19	2.2	**	**	16	4.9	−19.5#	−8.8
20	2.1	1.0	−0.3	15	3.9	1.6	0.7	21	2.1	**	**	20	2.9	3.2	0.2
32	0.8	**	**	21	1.4	−5.0	−1.0	15	2.9	**	**	25	1.3	**	**
	401.6	−0.2	1.1		301.2	0.3	7.2		229.8	−1.7#	−58.9		309.0	0.1	−1.0
1	120.2	−0.2	−1.6	1	92.8	1.5#	8.1	1	60.7	−3.5#	−22.9	1	88.2	0.6	1.9
3	53.6	0.5	2.8	3	28.4	0.0	−1.2	3	25.8	−2.8#	−10.2	3	24.1	−1.5#	−3.4
2	55.9	−0.1	−2.3	2	39.3	0.0	−0.1	2	32.3	−1.0	−9.5	2	32.3	−0.2	−1.3
4	18.4	1.8#	6.0	4	17.0	1.6#	3.3	4	10.1	**	−1.6	5	16.6	0.7	1.7
7	10.9	2.5#	2.1	7	11.2	1.2	2.4	9	6.9	**	††	6	13.3	0.4	0.7
8	10.3	−1.6#	−0.9	9	10.4	0.3	1.4	5	8.9	**	−2.6	7	11.9	0.2	0.5
29	0.8	**	**	21	1.4	4.4	0.6	19	1.9	**	**	17	4.1	2.8	0.7
5	14.7	−1.6#	−0.9	10	8.3	2.0#	1.5	8	7.3	**	**	10	9.4	0.2	1.0
15	5.5	4.5#	2.4	6	11.7	2.0#	1.5	11	6.1	2.3	0.7	9	9.7	2.9#	3.0
6	12.6	−3.8#	−4.4	8	10.5	−4.9#	−4.3	10	6.6	−6.9#	−6.3	4	17.3	−3.3#	−6.3
12	8.0	−1.2	−1.1	12	6.2	−2.2#	−0.8	13	4.5	**	**	12	7.7	−0.6	−0.4
13	7.5	0.9	1.0	14	4.2	−1.3	−1.7	18	2.0	**	**	14	5.2	0.3	0.5
11	9.1	2.5#	3.3	15	4.1	2.8#	1.3	7	7.9	**	−3.4	11	7.8	2.7#	2.7
14	6.5	−1.7#	−0.3	13	5.8	−0.1	−0.7	14	4.0	**	**	18	4.0	−1.3	0.0
10	9.7	0.0	0.4	5	12.9	−2.9#	−4.0	6	7.9	**	**	8	10.2	−0.6	−1.2
18	3.5	−1.3	−0.4	16	3.0	−1.6	0.4	20	1.6	**	**	15	4.6	0.6	0.4
9	10.1	−1.8#	−1.4	17	2.8	1.5	0.1	16	3.5	**	**	16	4.4	−0.1	−0.1
17	3.6	1.4	0.1	11	7.9	0.2	0.4	12	5.6	**	**	13	5.4	5.0#	2.6
24	1.6	0.2	0.3	20	1.7	−4.0	−1.2	15	3.9	**	**	19	4.0	−3.0	−0.5

*Sources of data are the Surveillance, Epidemiology, and End Results (SEER) Program registries that include Connecticut, Hawaii, Iowa, Utah, and New Mexico; the metropolitan areas of San Francisco, Detroit, Atlanta, Seattle-Puget Sound, San Jose-Monterey, and Los Angeles; rural Georgia and Alaska Natives in Alaska (i.e., SEER13). Cancers are sorted in descending order according to sex-specific rates for all races. More than 15 cancers may appear for males and females to include the 15 most common cancers in every racial and ethnic group. APC = annual percent change; AC = absolute change; API = Asian/Pacific Islander; AI/AN = American Indian/Alaska Native; NOS = not otherwise specified.

†Data for Hispanics/Latinos excludes cases diagnosed in Detroit, Hawaii, Alaska Natives, and rural Georgia.

‡Rates are per 100 000 persons and are age-adjusted to the 2000 U.S. Standard Population (using 19 age groups, with data provided from U.S. Bureau of the Census, Current Population Reports, Series P25-1130.

§APC is based on rates that were age-adjusted to the 2000 US Standard Population (using 19 age groups, with data provided from U.S. Bureau of the Census, Current Population Reports, Series P25-1130) *(39)*.

‖AC was calculated as the difference in the age-adjusted rate for 2002 minus age-adjusted rate for 1992.

¶All sites excludes myelodysplastic syndromes and borderline tumors; ovary excludes borderline tumors.

#APC is statistically significantly different from zero (two-sided $P<.05$).

**Statistic could not be calculated. APC based on fewer than 10 cases for at least 1 year during the time interval.

††Excludes borderline tumors.

patients who received adjuvant therapy for colon and rectal cancer increased rapidly between 1987 and 1992, following publication of results of relevant clinical trials in 1989 and 1990 *(56,57)* and the 1990 NIH Consensus Conference *(54)*. However, dissemination of adjuvant therapy varied with patient age, with much lower rates of treatment among older patients. Not surprisingly, given the lack of positive evidence from randomized clinical trials, treatment rates were lower for patients with stage II disease than for patients with stage III disease. Treatment patterns for colon and rectal cancers have also been examined using SEER-Medicare data, and the findings of the POC/QOC studies have largely been corroborated *(32,58–64)*.

A SEER-Medicare analysis examined the association between adjuvant therapy and patient characteristics. For Medicare

Table 4. U.S. death rates and trends for the 15 most common cancers by sex and race/ethnicity for 1992 through 2002*

Sex/cancer site or type	All races				Whites			
	Rank	Rate‡	APC§	AC‖	Rank	Rate‡	APC§	AC‖
Male								
All sites		258.6	−1.5¶	−36.7		252.5	−1.4¶	−32.9
Lung and bronchus	1	80.8	−1.9¶	−14.5	1	79.3	−1.7¶	−13.3
Prostate	2	33.9	−3.6¶	−11.1	2	31.2	−3.7¶	−10.5
Colon and rectum	3	26.3	−2.0¶	−5.5	3	25.8	−2.2¶	−5.8
Pancreas	4	12.3	−0.3¶	−0.5	4	12.0	0.0	−0.2
Non−Hodgkin lymphoma	5	10.4	−0.7	−0.7	5	10.8	−0.7	−0.7
Leukemia	6	10.4	−0.7¶	−0.6	6	10.6	−0.6¶	−0.6
Urinary bladder	7	7.7	−0.6¶	−0.4	7	8.0	−0.5¶	−0.3
Esophagus	8	7.6	0.6¶	0.5	8	7.2	1.6¶	1.1
Stomach	9	7.1	−3.4¶	−2.2	9	6.3	−3.6¶	−2.1
Liver and intrahepatic bile duct	10	6.5	2.1¶	1.4	12	5.9	2.1¶	1.3
Kidney and renal pelvis	11	6.2	−0.1	−0.1	10	6.2	−0.1	−0.1
Brain and other nervous system	12	5.7	−0.7¶	−0.4	11	6.1	−0.7¶	−0.4
Myeloma	13	4.8	−0.5¶	0.0	13	4.5	−0.3	0.2
Oral cavity and pharynx	14	4.5	−2.7¶	−1.1	15	4.2	−2.3¶	−0.8
Melanoma of the skin	15	3.9	−0.1	−0.1	14	4.4	0.0	0.0
Larynx	16	2.7	−2.5¶	−0.7	16	2.4	−2.3¶	−0.6
Soft tissue including heart	17	1.6	−1.3¶	−0.2	17	1.6	−1.2¶	−0.2
Female								
All sites		169.2	−0.7¶	−11.6		167.9	−0.7¶	−10.7
Lung and bronchus	1	40.3	0.6¶	2.8	1	41.1	0.7¶	3.4
Breast	2	28.5	−2.4¶	−6.1	2	28.0	−2.5¶	−6.5
Colon and rectum	3	18.3	−1.8¶	−3.3	3	17.8	−1.9¶	−3.4
Pancreas	4	9.2	−0.1	−0.1	5	8.9	0.0	0.0
Ovary	5	9.0	−0.5¶	−0.4	4	9.3	−0.4	−0.3
Non−Hodgkin lymphoma	6	6.8	−0.9	−0.5	6	7.1	−0.9	−0.6
Leukemia	7	5.9	−0.6¶	−0.4	7	6.0	−0.5¶	−0.4
Corpus and uterus, NOS	8	4.1	−0.1	−0.1	9	3.9	−0.2	−0.1
Brain and other nervous system	9	3.8	−1.1¶	−0.4	8	4.1	−1.0¶	−0.4
Stomach	10	3.4	−2.6¶	−0.9	10	3.0	−2.9¶	−0.9
Myeloma	11	3.2	−0.4	−0.1	11	2.9	−0.4¶	0.0
Cervix uteri	12	3.0	−3.1¶	−1.0	13	2.7	−2.7¶	−0.7
Liver and intrahepatic bile duct	13	2.9	1.2¶	0.4	14	2.7	1.1¶	0.4
Kidney and renal pelvis	14	2.8	−0.4	−0.1	12	2.9	−0.4	−0.1
Urinary bladder	15	2.3	−0.4	−0.1	15	2.3	−0.3	0.0
Esophagus	17	1.8	−0.2	−0.1	18	1.6	0.7¶	0.1
Oral cavity and pharynx	18	1.7	−2.4¶	−0.4	17	1.7	−2.3¶	−0.4
Gallbladder	20	0.9	−2.5¶	−0.3	20	0.9	−2.7¶	−0.3

(Table continues)

patients aged 65 years or older who were diagnosed with stage III colon cancer from 1997 through 1999, SEER-Medicare data are available on patients' receipt of adjuvant therapy by patient age at diagnosis and the number of comorbid conditions (Table 7) *(32)*. Although receipt of postoperative adjuvant chemotherapy was inversely associated with the number of preexisting concurrent conditions, the likelihood of receiving adjuvant therapy decreased with age, even when comorbidity was taken into account. These data also show that among elderly patients the rates of hospitalization for complications from chemotherapy increased modestly with increasing age.

The specific reasons for the failure to receive treatment are not directly documented in SEER-Medicare data. However, because Medicare claims permit ascertainment of referral patterns, Schrag et al. *(32)* found that most colon cancer patients who did not receive chemotherapy never had a consultation with a medical oncologist. This observation suggests that more research is needed to determine how referral and access to specialty physicians may influence whether patients receive appropriate treatment.

Provider and patient perceptions and preferences also influence treatment. To supplement SEER registry data from northern California, Ayanian et al. *(64)* performed physician interviews and extensive medical record reviews for patients who were diagnosed with stage III colon cancer or with stage II or III rectal cancer from 1996 through 1997. They found that 88% of patients younger than 55 years of age received adjuvant treatment, compared with only 11% of patients older than 85 years. Physician interviews revealed that patient refusal (30%), comorbid illness (22%), and lack of perceived clinical benefit (22%) were the most common reasons that adjuvant therapy was not delivered.

Trends in Lung Cancer Treatment. Several studies have been conducted on patterns of care for patients with stage IV NSCLC. Although treatment for advanced-stage NSCLC is not without controversy *(34)*, published guidelines *(65,66)* indicate that chemotherapy may be beneficial for patients whose cardiopulmonary status is adequate to allow them to undergo the treatment.

Three studies examined the use of chemotherapy in patients aged 65 or older at diagnosis with stage IV NSCLC. By using instrumental variable analysis and propensity score techniques to analyze SEER-Medicare data, Earle et al. *(67)* found that the estimated survival benefits for stage IV NSCLC patients aged 65 years or older who were treated with chemotherapy were similar to the survival benefits found in randomized trials of younger patients. In another study using SEER-Medicare data, Earle et al. *(34)* found that 22% of stage IV NSCLC patients diagnosed from 1991 through 1993 received chemotherapy. Using NCI

Table 4 (continued).

Blacks				API				AI/AN				Hispanics/Latinos†			
Rank	Rate‡	APC§	AC‖	Rank	Rate‡	APC§	AC‖	Rank	Rate‡	APC§	AC‖	Rank	Rate‡	APC§	AC‖
	360.5	−2.0¶	−66.3		155.7	−2.0¶	−32.2		165.5	−1.2	−25.5		175.7	−0.9¶	−12.3
1	109.1	−2.5¶	−25.4	1	41.1	−1.9¶	−8.9	1	50.0	−2.3	−9.9	1	40.4	−1.5¶	−3.9
2	73.7	−2.5¶	−16.9	4	14.1	−5.2¶	−6.5	2	21.5	−4.5¶	−11.5	2	24.7	−2.4¶	−3.9
3	34.8	−0.8¶	−2.9	2	16.4	−1.5¶	−2.4	3	16.1	1.7	4.2	3	17.9	−0.4	−0.8
4	16.4	−1.5¶	−2.8	6	8.4	−2.1¶	−0.4	7	6.3	1.4	0.9	6	9.4	−0.8	−0.8
11	7.4	−0.6	−0.4	7	6.6	−2.2¶	−1.8	9	5.1	1.1	−0.1	7	8.0	−1.1	−1.4
7	9.3	−1.1¶	−0.6	8	5.4	−1.1	−0.7	8	5.1	−3.3	−0.8	8	6.7	0.2	0.0
13	5.9	−2.0¶	−1.1	11	2.9	0.6	−0.2	13	2.5	#	#	11	4.2	−0.7	−0.2
6	12.9	−4.4¶	−4.9	10	3.6	−3.7¶	−2.1	10	4.8	1.5	0.8	10	4.5	−1.2¶	−0.5
5	14.1	−3.0¶	−3.5	5	12.6	−3.9¶	−5.6	5	7.4	−1.7	−2.7	5	10.0	−2.1¶	−2.1
8	9.2	1.3¶	1.5	3	15.9	−0.6	−0.1	4	7.6	1.6	0.0	4	10.2	1.6¶	2.1
12	6.2	0.1	−0.1	12	2.7	−0.2	−0.3	6	6.8	0.8	−0.2	9	5.5	0.7	0.2
15	3.3	−0.8¶	−0.2	13	2.4	3.0¶	1.2	14	2.4	0.9	0.6	13	3.5	0.5	0.2
9	9.1	−1.2¶	−1.1	14	2.2	−2.4	−0.2	12	3.3	#	−1.5	12	3.8	1.1	0.6
10	8.2	−4.6¶	−3.7	9	3.8	−2.8¶	−1.3	11	3.6	−1.5	−0.5	14	3.2	−4.0¶	−1.2
23	0.5	−0.5	−0.1	20	0.5	#	−0.2	18	0.9	#	#	17	1.1	−0.6	−0.1
14	5.7	−2.9¶	−1.5	16	0.9	−1.2	−0.4	15	1.9	#	#	15	2.2	−3.2¶	−0.6
16	1.6	−0.3	0.0	15	1.1	−4.4¶	−0.3	19	0.8	#	#	16	1.2	−0.8	0.2
	199.2	−0.8¶	−14.9		102.3	−1.1¶	−8.5		115.2	−0.3	−1.0		112.1	−0.4¶	−7.1
1	39.3	0.4¶	1.7	1	19.0	−0.4	−1.0	1	26.4	1.0	4.4	2	14.9	0.1	0.0
2	36.2	−1.2¶	−3.0	2	12.9	−0.6	−0.1	2	14.4	−1.5	−1.5	1	17.7	−1.9¶	−3.8
3	24.7	−0.9¶	−2.6	3	11.3	−2.2¶	−2.0	3	12.1	−0.2	2.6	3	11.5	0.1	−0.3
4	12.9	−0.8¶	−1.1	5	6.7	0.9	1.1	4	6.1	0.1	−0.3	4	7.6	0.2	−0.1
5	7.6	−0.8¶	−0.8	7	4.8	0.0	0.1	5	5.1	−0.4	−1.4	5	6.2	−0.6	−1.2
11	4.5	−0.3	0.0	8	4.1	−0.9	−0.5	8	3.8	2.4	−0.4	7	5.3	0.1	0.6
10	5.5	−0.7¶	−0.3	9	3.4	−1.6	0.6	10	3.4	−1.2	0.4	9	4.3	−0.6	−0.3
6	7.0	0.2	0.3	11	2.2	1.4	0.4	13	2.6	0.3	0.4	11	3.2	0.6	0.1
16	2.3	−0.6	−0.2	12	1.6	−3.3¶	−0.2	15	1.6	#	−0.2	13	2.5	0.6	0.0
7	6.7	−2.1¶	−1.4	4	7.5	−3.5¶	−2.4	6	4.2	0.0	0.0	6	5.5	−1.5¶	−0.9
8	6.5	−0.5	−0.3	13	1.6	1.7	0.3	12	2.7	#	0.1	12	2.7	1.4	0.6
9	6.2	−4.9¶	−3.1	10	2.9	−3.3¶	−1.1	11	3.2	−4.7¶	−1.9	10	3.8	−3.0¶	−1.2
12	3.7	0.7	0.3	6	6.5	−0.7	−0.9	7	4.1	1.7	−0.1	8	4.8	2.1¶	0.7
15	2.8	0.0	0.2	15	1.2	0.3	0.2	9	3.4	−1.1	1.2	14	2.4	−0.5	0.0
14	3.0	−0.6	0.0	16	1.1	−2.2	−0.3	18	1.1	#	#	16	1.3	1.6	0.5
13	3.5	−3.3¶	−1.2	18	0.9	−1.1	−0.1	17	1.1	#	#	18	0.9	1.7	0.3
17	2.1	−3.5¶	−0.6	14	1.5	−1.2	0.2	16	1.3	#	0.1	19	0.9	−1.2	−0.4
19	1.1	−0.2	0.1	17	1.0	−6.3¶	−1.1	14	1.7	#	−1.1	15	1.8	−3.2¶	−0.9

*Source of data is the National Center for Health Statistics public–use data file for the total United States. Cancers are sorted in descending order according to sex–specific rates for all races. More than 15 cancers may appear under male and female to include the 15 most common cancers in every racial and ethnic group. APC = annual percent change; AC = absolute change; API = Asian/Pacific Islander; AI/AN = American Indian/Alaska Native; NOS = not otherwise specified.

†Data for Hispanics/Latinos excludes cases diagnosed in Connecticut, Maine, Maryland, Minnesota, New Hampshire, New York, North Dakota, Oklahoma, and Vermont.

‡Rates are per 100 000 persons and are age–adjusted to the 2000 U.S. Standard Population (using 19 age groups, with data provided from US Bureau of the Census, Current Population Reports, Series P25–1130 *(39)*.

§APC is based on rates that were age–adjusted to the 2000 U.S. Standard Population (using 19 age groups, with data provided from U.S. Bureau of the Census, Current Population Reports, Series P25–1130) *(39)*.

‖AC was calculated as the difference in the age–adjusted rate for 2002 minus age–adjusted rate for 1992.

¶APC is statistically significantly different from zero (two–sided $P<.05$).

#Statistic could not be calculated. APC based on fewer than 10 cases for at least 1 year within the time interval.

POC/QOC data for stage IV NSCLC patients diagnosed in 1996, Potosky et al. *(33)* found a similar level of treatment among patients aged 65 years or older. The use of chemotherapy in patients 65 years or older diagnosed with stage IV NSCLC is little more than 20%. However, data *(67)* suggest that patients in this age group might have survival similar to that of younger patients if they receive chemotherapy.

In addition to age and stage at diagnosis, other factors influence receipt of chemotherapy. Among patients with stage IV NSCLC, Earle et al. *(34)* also found that younger patients and patients who had fewer comorbid conditions were more likely to receive chemotherapy than older patients and patients who had more comorbid conditions. In addition, they found that several nonclinical factors—white race, higher socioeconomic status, geographic location (i.e., patients in Utah and New Mexico received chemotherapy statistically significantly less often and patients in Seattle/Puget Sound and Los Angeles County received chemotherapy statistically significantly more often than patients in other SEER geographic regions) *(24)*, and receiving treatment in a teaching hospital—were associated with the receipt of chemotherapy. Results of the study by Potosky et al. *(33)* also echoed several of these findings. In a subsequent study of SEER-Medicare data, Earle et al. *(68)* found that nonclinical factors were also important determinants of whether a patient with stage IV NSCLC was even seen by an oncologist; however, among patients who had seen an oncologist, treatment decisions were

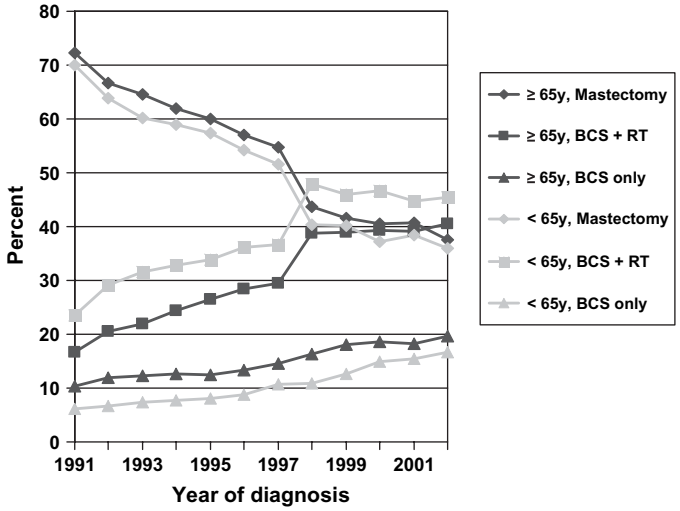

Fig. 1. Treatment for early-stage breast cancer, 1991–2002, by age at diagnosis. BCS = breast-conserving surgery; RT = radiation treatment. Source: Surveillance, Epidemiology, and End Results (SEER) 11 registries (Connecticut, Hawaii, Iowa, Utah, and New Mexico and the metropolitan areas of San Francisco, Detroit, Atlanta, Seattle-Puget Sound, San Jose-Monterey, and Los Angeles County).

related mainly to clinically relevant factors, such as age and comorbidity.

Potosky et al. *(33)* also examined the receipt of appropriate surgical treatment for patients with stage I or II NSCLC, the receipt of surgical treatment and chemoradiation for patients with stage IIIA NSCLC, and the receipt of chemoradiation for patients with stage IIIB NSCLC. These investigators found, as did Bach et al. *(69)* in an earlier study of SEER-Medicare data, that white patients were substantially more likely to receive surgery for stage I and II NSCLC than black patients, even after adjustments had been made for other sociodemographic factors. In addition, Potosky et al. *(33)* found a similar racial disparity in surgical rates for white and black patients with stage III NSCLC.

Trends in Ovarian Cancer Treatment. A 1994 NIH Consensus Conference *(70)* defined guideline treatment for ovarian cancer to include adequate and complete surgical intervention as the primary therapy for ovarian carcinoma, which would permit precise staging, accurate diagnosis, and optimal cytoreduction. Subsequent phase III clinical trials have established platinum-based chemotherapy combined with a taxane as the standard of care for ovarian cancer *(71)*.

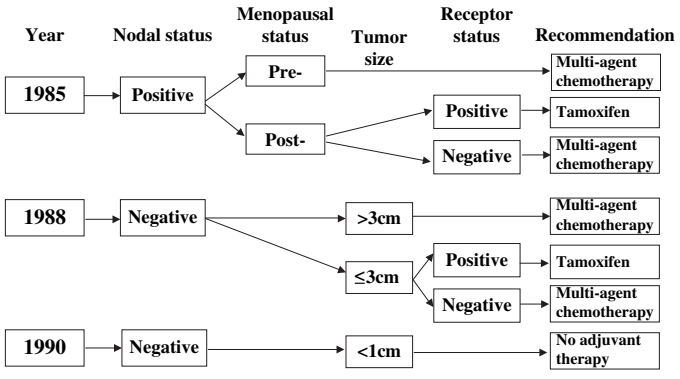

Fig. 2. Recommended adjuvant treatment for early-stage breast cancer *(30)*.

Table 5. Distribution of adjuvant therapy for women diagnosed with stage I–IIIA breast cancer by nodal status, age at diagnosis, and diagnosis year*

	Adjuvant therapy by diagnosis year (%)			
Nodal status and age	1987 (n = 902)	1990 (n = 1722)	1995 (n = 1474)	2000 (n = 1160)
Node-positive				
<51 years				
Chemotherapy alone	68.1	63.0	58.1	37.5
Chemotherapy + tamoxifen	13.5	23.1	31.0	51.5
Tamoxifen alone	3.9	2.3	3.4	2.9
Neither/unknown	14.5	11.6	7.5	8.1
51–64 years				
Chemotherapy alone	13.4	35.8	30.5	25.5
Chemotherapy + tamoxifen	31.9	24.6	37.6	56.2
Tamoxifen alone	32.4	26.1	20.4	6.2
Neither/unknown	22.3	13.5	11.5	12.1
≥65 years				
Chemotherapy alone	6.3	13.8	11.1	21.4
Chemotherapy + tamoxifen	8.0	12.6	32.9	18.8
Tamoxifen alone	65.6	55.2	42.7	36.2
Neither/unknown	20.1	18.5	13.3	23.7
Node-negative				
<51 years				
Chemotherapy alone	12.8	31.1	34.0	33.5
Chemotherapy + tamoxifen	1.2	8.5	13.3	30.4
Tamoxifen alone	2.5	13.2	15.8	14.8
Neither/unknown	83.5	47.1	36.9	21.3
51–64 years				
Chemotherapy alone	2.6	9.4	13.7	15.6
Chemotherapy + tamoxifen	0	6.6	10.5	10.4
Tamoxifen alone	4.6	37.2	40.4	44.5
Neither/unknown	92.9	46.9	35.5	29.1
≥65 years				
Chemotherapy alone	1.0	2.3	1.9	9.2
Chemotherapy + tamoxifen	1.0	4.9	1.6	2.1
Tamoxifen alone	11.8	38.8	52.3	44.9
Neither/unknown	86.2	54.0	44.2	43.8
Node-negative and tumor <1 cm				
Chemotherapy alone	0.6	5.9	3.8	1.6
Chemotherapy + tamoxifen	0	0.6	2.1	1.1
Tamoxifen alone	2.8	26.4	34.3	35.0
Neither/unknown	96.6	67.1	59.8	62.2

*Data for 1987, 1990, and 1995 are from Harlan et al. *(30)* and data for 2000 are from an National Cancer Institute Patterns of Care/Quality of Care study of Surveillance, Epidemiology, and End Results Program registries (SEER11) (Harlan LC, Clegg LX, Abrams J, Sterens JL, Ballard-Barbash R.: manuscript submitted).

Harlan et al. *(35)* examined patterns of care for ovarian cancer among women who were diagnosed with ovarian cancer in 1991 and in 1996. They found that a large percentage of the ovarian cancer patients diagnosed in 1991 (before the 1994 guidelines were published)—particularly those diagnosed with stage I and II ovarian cancer—did not receive node dissection, nor did they receive the therapies that were subsequently recommended in the 1994 guidelines (Table 8). By 1996, however, there were notable improvements in the treatment of stage I and II ovarian cancer patients, primarily because of increasing rates of lymph node dissection. Even so, Harlan et al. *(35)* found that a substantial proportion of stage I and II ovarian cancer patients still did not receive lymph node dissection in 1996, and many stage III and

Table 6. Distribution of adjuvant therapy for patients diagnosed with stage II or III colon or rectal cancer by age at diagnosis and diagnosis year*

Site/stage of cancer and patient age (y)	Offered or received adjuvant therapy by diagnosis year (%)		
	1987 (n = 265)	1991 (n = 265)	1995 (n = 257)
Colon cancer			
Stage II			
<55	0.0	39.8	44.3
55–74	4.5	28.1	32.5
≥75	6.1	8.6	15.6
Stage III			
<55	11.6	55.8	87.0
55–74	3.4	72.6	65.2
≥75	5.5	27.3	43.3
Rectal cancer	n = 464	n = 478	n = 423
Stage II			
<55	21.4	75.3	75.4
55–74	20.7	53.9	65.4
≥75	2.7	23.3	45.7
Stage III			
<55	37.7	92.8	92.5
55–74	32.8	86.4	84.6
≥75	14.1	38.1	50.7

*Adjuvant therapy for colon cancer = 5-fluorouracil–based combination chemotherapy. Adjuvant therapy for rectal cancer = 5-fluorouracil–based chemotherapy with or without radiation treatment. Data are adapted from Potosky et al. *(31)*.

IV patients who were diagnosed in 1996 did not receive platinum-based chemotherapy.

However, Harlan et al. *(35)* also found that, between 1991 and 1996, a major shift occurred in the type of chemotherapy that women with ovarian cancer had received. Specifically, the use of cyclophosphamide decreased whereas the use of paclitaxel, the taxane that initially had been approved for the treatment of ovarian cancer by a Food and Drug Administration advisory committee in 1992, had increased rapidly *(72)*.

In addition, the authors *(35)* found that women with stage III or IV ovarian cancer were less likely to receive guideline-based treatment if they lacked private insurance or were older than 65 years at diagnosis. Several other studies *(73,74)* of the SEER-Medicare data for ovarian cancer patients diagnosed in 1992 through 1996 similarly found that, within the Medicare population, older age at diagnosis was associated with lower odds of receiving chemotherapy, especially among patients with stage III and IV disease *(73,74)*, although patients who did receive chemotherapy experienced improvements in survival, consistent with previous clinical trial results *(75)*.

Harlan et al. *(35)* also noted a relationship between the presence of an approved residency training program at a given hospital and the proportion of ovarian cancer patients receiving guideline-based treatment. This observation suggests that the receipt of guideline-based treatment may be a function of access to oncologists with expertise in the management of ovarian cancer. A recent study of SEER-Medicare data *(76)* found that only 34% of female Medicare beneficiaries had their ovarian cancer resection performed by a gynecologic oncologist; 46% were operated on by a gynecologist, and 20% were operated on by a general surgeon. After adjusting for differences in stage at diagnosis, age, and other factors, it appeared that women who were operated on by gynecologic oncologists had somewhat more favorable outcomes than women who were operated on by gynecologists or general surgeons.

Trends in Prostate Cancer Treatment. Whereas breast, colorectal, lung, and ovarian cancers have well-established treatment guidelines, treatment for prostate cancer is more controversial. SEER registry, NCI POC/QOC, and SEER-Medicare data have been used extensively to study trends in prostate cancer treatment, variations in and determinants of treatment, and quality-of-life–related treatment outcomes *(36,37,77–82)*. These topics have also been explored in a large NCI-sponsored prospective cohort study, the Prostate Cancer Outcomes Study *(83–87)*.

Trends in treatment for early-stage prostate cancer among white and black patients diagnosed in 1986 through 1999 were examined using SEER-Medicare data *(36,37)* (Fig. 3). The most notable trend in prostate cancer treatment was the decline in the proportion of patients who received conservative management (defined as watchful waiting, surgical or chemical castration, or hormonal androgen deprivation therapy) as primary treatment. In addition, over the entire period, black men were substantially less likely than white men to receive aggressive treatment (defined as radical prostatectomy, external beam radiation therapy, or brachytherapy). The use of hormonal androgen deprivation therapy increased sharply during the 1990s among prostate cancer patients who received conservative management or radiation treatment. The percentage of men

Table 7. Distribution of postoperative adjuvant chemotherapy and hospitalization after surgery among beneficiaries in the SEER-Medicare database diagnosed with stage III colon cancer from 1997 through 1999, by age at diagnosis*

	Patient age at diagnosis, (%)					
	All patients (n = 2996)	65–69 y (n = 564)	70–74 y (n = 727)	75–79 y (n = 708)	80–84 y (n = 550)	≥85 y (n = 447)
Postoperative adjuvant chemotherapy initiated within 3 months of surgery						
Total patients	58.5	79.4	71.5	62.9	41.8	11.0
No. of comorbid conditions						
0	67.4	83.9	79.6	73.0	54.3	15.4
1	52.1	77.4	69.9	59.6	34.5	7.8
≥2	41.6	67.6	57.9	48.6	31.7	8.2
Hospitalized within 6 months of receiving postoperative adjuvant chemotherapy						
Any hospitalization	26.8	23.8	26.3	26.8	31.4	33.3
Hospitalization for complications of chemotherapy	9.3	7.0	9.1	10.8	12.2	9.8

*Data are from Schrag et al. *(32)* and were updated February 2005 by using data from Surveillance, Epidemiology, and End Results (SEER) Program-Medicare databases.

Table 8. Ovarian cancer patients' receipt of 1994 National Institute of Health consensus guideline therapy by stage and diagnosis year*

	n (%) in diagnosis year	
	1991	1996
Stage I, grade unknown		
No guideline therapy; no tumor grade	69 (100)	40 (100)
Stage I, grades 1 to 4		
Guideline therapy†	45 (36.8)	68 (61.7)
No guideline therapy		
No lymph node dissection	71 (60.1)	39 (35.5)
No stage-appropriate surgery	4 (3.1)	3 (2.8)
Stage II		
Guideline therapy‡	7 (14.2)	21 (38.4)
No guideline therapy		
No lymph node dissection	37 (71.8)	22 (48.7)
No stage-appropriate surgery	5 (8.7)	3 (8.0)
Stage III and IV		
Guideline therapy§	225 (62.6)	229 (62.3)
No guideline therapy		
No stage-appropriate surgery	85 (23.7)	98 (25.1)
No platinum-based chemotherapy	50 (13.7)	40 (12.6)

*Percentages are weighted to take sampling design into account. Data adapted from Harlan et al. *(35)*. The 1994 National Institutes of Health consensus guideline is available at http://consensus.nih.gov/previousstatements.htm.

†Lymph node dissection; subtotal or partial oophorectomy or more extensive surgery through omentectomy, excluding debulking; histologic grade of the tumor determined.

‡Lymph node dissection; subtotal or partial oophorectomy or more extensive surgery through omentectomy, excluding debulking; platinum-based chemotherapy.

§Subtotal or partial oophorectomy or more extensive surgery, including debulking; platinum-based chemotherapy.

treated with brachytherapy increased during the 1990s but still accounted for a relatively low proportion of all treatment *(37)*.

Other Aspects of Cancer Treatment

Provider Procedure Volume–Outcome Relationships in Cancer Treatment. Studies of relationships between provider procedure volume and patient outcomes have, in general, found that higher procedure volume at the physician and/or hospital levels, especially for complex surgical procedures, are associated with better outcomes, including lower short-term mortality rates and improved long-term survival *(61–63,88,89)*. Several studies have been initiated to explore the components of provider procedure volume that may explain the link between volume and cancer patient outcomes, including the practice style of the physician and differences in the characteristics of patients served by different types of hospitals or providers *(90,91)*.

Care for Cancer Patients During the Last Year of Life. The SEER-Medicare database contains information about medical care that was received over the entire course of a disease, which is useful for monitoring trends in treatment. Recently, Earle et al. *(92)* used this information to track trends in end-of-life cancer care for patients with lung, breast, colorectal, and other gastrointestinal cancers. They found that from 1993 through 1996 there was a decrease in the proportion of cancer patients who died in an acute care hospital, with more patients using hospice services in 1996 than in 1993, but an increasing proportion of them enlisted this assistance during the last 3 days of life. Among those who received chemotherapy in 1996, 18.5% were still receiving treatment within 2 weeks of death, an increase from 13.8% in 1993. From 1993 through 1996, there was also an increase in the proportion of patients who, during the last months of life, had more than one emergency department visit, were hospitalized, or were admitted to an intensive care unit.

Cost of Treatment. Various aspects of the economic cost of cancer treatment have also been examined in studies that have used SEER-Medicare data *(93–96)*, data from the Medical Expenditure Panel Survey conducted by the Agency for Healthcare Research and Quality (AHRQ) *(97)*, and data from large nonprofit HMO delivery systems linked to SEER data *(98–100)*. Results of these studies have been used as baseline inputs for cost-effectiveness studies of new early detection and treatment innovations. Efforts to describe national long-term trends in cancer treatment costs and to describe resource-based components of these trends are currently underway.

Discussion

Overall Cancer Incidence and Mortality Trends in the United States

Progress has been achieved in reducing the cancer burden in the United States. The decline in overall cancer death rates that

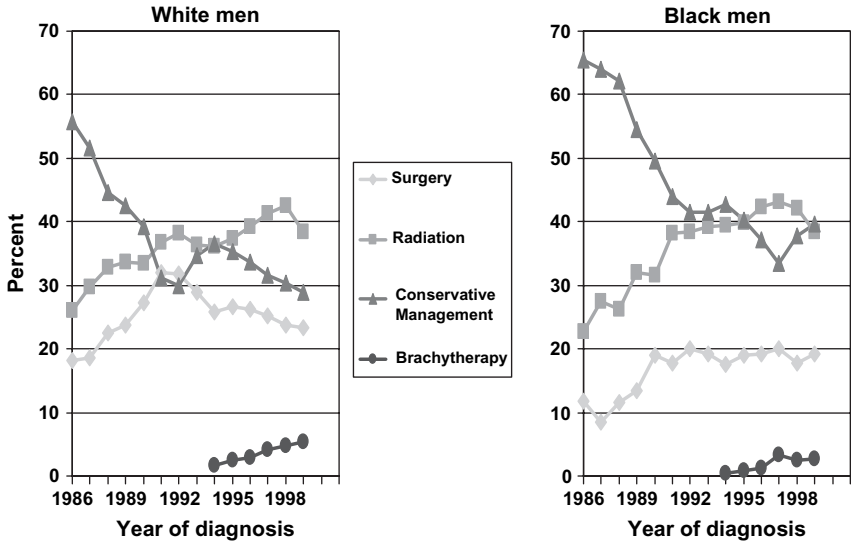

Fig. 3. Trends in treatment for early-stage prostate cancer, 1986–1999, SEER-Medicare. Adapted from Klabunde et al. *(36)* and from Zeliadt et al. *(37)*.

began in the early 1990s occurred after more than six decades of reported increases in cancer mortality. The historical trends in age-adjusted cancer death rates have been documented for 10 types of cancer by sex *(101)*. Before the 1950s, annual cancer death rates for all sites had increased by more than 1% per year until the early 1970s, when they slowed to half this rate; they then began to decrease in 1993 by 1.1% per year. Declines in overall cancer death rates have occurred in both men and women and for many of the 15 most common cancers, including cancers of the lung, colon and rectum, and prostate in men and cancers of the colon and rectum and breast in women. For many cancers, these declines have occurred because of effective prevention and risk-reduction interventions, screening and early detection, and improved treatments and medical management. Nevertheless, the demographic phenomena of aging and increasing size of the U.S. population have contributed to an increase in the absolute total number of cancer deaths *(5)*.

Changes in cancer incidence over time may result from changes in the prevalence of risk factors, from changes in detection practices due to the introduction or increased use of screening or diagnostic techniques, and from delays in reporting *(1–7)*. Trends in overall reporting of delay–adjusted cancer incidence rates for all cancers combined stabilized from 1995 through 2002 among men, and among women increased by 0.3% annually from 1987 through 2002, a slower pace than the annual increase observed from 1975 through 1987. The overall trend in cancer incidence for both sexes combined appears to have been heavily influenced both by the rapidly changing prostate cancer incidence trends among men *(102,103)* and by delays in reporting *(45)*. The increase in overall cancer incidence rates for women can be attributed to increases in the incidence rates for breast cancer, non-Hodgkin lymphoma, melanoma, thyroid cancer, leukemia, and bladder and kidney cancer.

The slight but statistically significant increase in the overall age-adjusted female lung cancer death rate from 1995 through 2002 represents a change from the trend described in the 2004 annual report to the nation *(7)*, in which the rates from 1995 through 2001 were reported to be stable. This change may reflect random variations in the rates as the trend stabilized before showing what is expected to be a steady decline. Lung cancer mortality trends in the United States are determined largely by historical smoking patterns *(104–106)*. Smoking prevalence in women peaked among those who were born in the late 1930s and began to decrease among women born thereafter through 1950 *(107)*. Thus, women who were born in the late 1930s and who are now aged 60 years or older are at an increased risk for lung cancer. As these women with the highest risk of lung cancer age and because lung cancer death rates in the future are calculated using a larger proportion of women with a lower risk of lung cancer, the lung cancer mortality trend in women may fluctuate from year to year before it begins what is expected to be a steady decline *(7)*.

The recent increase in lung cancer death rates among women aged 40–49 years reflects the increased risk of lung cancer among women who were born after 1950 *(105,108)*. Smoking initiation rates in girls who were born from 1950 through 1960 increased from the mid-1960s to the late 1970s, a time during which specific brands of cigarettes were introduced and marketed to women *(106)*. The elevated lung cancer risk in women aged 40–49 years is unlikely to appreciably influence lung cancer mortality trends in the short term because of the small contribution of this age cohort (approximately 5%) to the overall age-standardized death rate *(108)*. However, the cohort of women aged 40–49 years who took up smoking in the mid-1960s and 1970s and are currently smoking can still substantially reduce their risk of dying from lung cancer by quitting smoking *(109)*. Women in their 40s who quit smoking have approximately one-third the risk of dying from lung cancer as women who continue to smoke *(109)*.

Our analyses of the 15 most common cancers within each race and ethnicity revealed that disparities in incidence persist, particularly among black men as compared with other groups. The cancer incidence rate for all sites combined was 25% higher in black men than in white men, and the incidence rates for black men were more than 50% higher than those in white men for myeloma and cancers of the prostate, lung, stomach, liver, esophagus, and larynx. Our analysis of the mortality data also revealed racial disparities. For example, the cancer death rate for all sites combined was 43% higher in black men than in white men, and death rates for myeloma and cancers of the prostate and stomach were more than 200% higher, whereas death rates for cancers of the esophagus and oral cavity were more than 75% higher.

In general, cancer incidence and death rates for API, AI/AN, and Hispanic/Latino populations were lower than those among black and white populations. However, some cancers, in particular stomach and liver cancer, disproportionately affect the API, AI/AN, and Hispanic/Latino populations. In our analysis, APIs had the highest rates of stomach and liver cancer among the populations studied, although stomach cancer death rates were highest among black men. Of note, the incidence and death rates of liver cancer increased for most population groups examined, suggesting that this once relatively rare cancer is becoming more common in the United States. Among men, incidence of gallbladder cancer was highest in the AI/AN population, even though these rates are probably underestimates due to the effects of undercounting and misclassification of the AI/AN race in case identification *(110)*. Finally, Hispanic/Latina women had the highest incidence rates of cancers of the cervix uteri and gallbladder among the populations studied, and AI/AN women had a similarly high incidence of gallbladder cancer.

As increasing numbers of population-based cancer registries meet high standards for the quality of their data to estimate incidence rates *(111)*, there is greater potential to investigate geographic as well as demographic variability in U.S. cancer incidence rates. Differences in sex- and race/ethnicity-specific incidence rates among states could result from variations in risk factor prevalence, in the use of screening tests for early detection, and/or in social and demographic factors *(6)*. Differences in cancer incidence rates among states may also reflect data that were based on small numbers and/or differences in aggregate rates derived from differential coverage of racial/ethnic populations. Differences in the incidence of specific cancers can be analyzed using the linked micromap plotting technique *(112)* available on the Cancer Control PLANET Web site *(113)*. Additional results are available at http://jncicancerspectrum.oupjournals.org/jnci/content/vol97/issue19 for data reported to NAACCR from 37 SEER and NPCR state (including the District of Columbia) cancer incidence registries that met NAACCR criteria for high-quality incidence data as of December 2004. Such registry data cover more than 77% of the U.S. population for data from 1998 through 2002.

Use of Cancer Registry-Based Data Resources to Monitor Cancer Treatment

Data regarding trends in and determinants of cancer treatment in the United States are available from a variety of sources *(114)*. In 1999, an Institute of medicine report *(9)* identified the two federal population-based registry programs in the United States—SEER and NPCR—as valuable resources for assessing the quality of cancer care.

In an editorial on patterns of care studies, Earle and Emanuel *(115)* stated that those concerned with the quality of health care delivery need to create "an environment of watchful concern," a term coined by Donabedian in 1966 *(116)*. Population-based cancer registries provide investigators with large numbers of cases and include all persons in the community. Data from registries can therefore be used to monitor the quality of care provided in a community setting. Studies that have used data from population-based registries have documented that much of contemporary cancer treatment is consistent with evidence-based NIH Consensus Development statements and other clinical guidelines concerning treatment.

Dissemination of guideline cancer treatments is not always rapid and complete. As a result, some aspects of recommended cancer treatment appear to be less than fully implemented in the community delivery setting. Examples of this failure include the modest but increasing use of breast-conserving surgery without radiation therapy to treat women diagnosed with early-stage breast cancer *(51)*, the possible overuse of chemotherapy for patients with stage II colon cancer *(31)*, and the receipt of less than adequate staging and treatment procedures for many women diagnosed with ovarian cancer *(35)*. Results of some studies also point to possible disparities in the receipt of cancer care with respect to patient age at diagnosis (for breast, colorectal, and ovarian cancers) *(30,31,35)*, race (for lung and prostate cancers) *(33,34,36,51)*, and type of health plan *(35,52)*. Such studies have begun to identify some of the factors that might be associated with appropriate processes and outcomes of care, such as provider procedure volume and referral practices.

It is important to note that substantial geographic variations in treatment patterns exist. Mandelblatt et al. *(117)* used Medicare data to examine initial treatment patterns for 3851 women diagnosed with early-stage breast cancer from 1992 through 1994 and found that surgeons' treatment propensity varied widely by region of the United States. For example, surgeons who practice in the Northeast region were most likely to perform breast-conserving surgery, and those in the South Atlantic region were most likely to perform mastectomy. These results underscore the need for more data on geographic patterns of cancer care, as well as the importance of developing a comprehensive and integrated national system of cancer registries.

Limitations and Issues in Interpretation

Several limitations in the data and methods may have influenced interpretations of the findings in this report. First, changes in detection practices due to the introduction or increased use of screening and diagnostic techniques may cause a temporal increase in observed incidence rates thus altering the stage distribution of the disease. Observed survival may be influenced through improved disease detection by advancing the time of diagnosis without prolonging life (lead-time bias), by the preferential detection of slower growing tumors (length–time bias), or by the detection of indolent cases that never would have been diagnosed in the absence of such diagnostic techniques (overdiagnosis bias) *(102,103,118–120)*. Improvements in staging techniques or changes in staging systems can influence the stage-specific biologic characteristics of tumors over time, making it difficult to interpret trends in cancer incidence.

Second, routinely collected statistics on cancer occurrence are commonly reported according to the five major racial and ethnic populations—white, black, API, AI/AN, and Hispanic/Latino. However, such broad racial and ethnic groupings may mask wide variations in the cancer burden by country of origin among, for example, APIs [whose countries of origin include China, Japan, Philippines, and Vietnam *(121,122)*] and Hispanic/Latino populations [whose countries of origin include Spain, Cuba, Puerto Rico, and Mexico *(123–125)*], or by cultural characteristics that define other high-risk populations, such as white residents of Appalachia *(126)*, recent immigrants, black populations in the rural South, and members of the more than 560 American Indian tribes that are recognized by the states and by the U.S. federal government *(127–130)*. Rates for populations other than white and black may be affected by problems in ascertaining race/ethnicity information from basic records (e.g., medical records, death certificates, and census reports) *(110,131)*.

Third, we used two different statistical methods to describe cancer trends. A single linear regression model was used to describe trends for a fixed time period (i.e., from 1992 through 2002) to allow comparisons of age-adjusted cancer incidence and death rates by race/ethnicity, sex, and cancer site. In addition, we used the joinpoint method to characterize long-term patterns (i.e., from 1975 through 2002) for all races and ethnicities combined. In some circumstances, these approaches may yield different results that may lead to different, even conflicting, interpretations due to the nature of the trends summarized by the two models. Of the two methods, the joinpoint method is more flexible and accurate in identifying the years in which there were statistically significant changes in trends.

Fourth, many treatment studies have limitations that include challenges in constructing measures of appropriate or guideline treatment, in generalizing to the general population, and in compensating for missing data. These studies have established the need for continued, more timely, and more detailed watchfulness. However, such studies are of limited use when there is no consensus regarding appropriate treatment. For some cancers, there are a range of acceptable treatments, and patterns-of-care studies can simply describe the care provided. The use of published guidelines to construct a measure of recommended therapy provides a conceptual basis for statistically analyzing community practice patterns collected from medical record data, but these recommendations may not always reflect the most appropriate management strategy for individual patients because of the heterogeneity of patient characteristics, even among patients with a particular stage of disease at diagnosis *(87)*.

The treatment studies described here rely primarily on cancer registry data from the SEER geographic regions. The ability to monitor treatment and extrapolate findings to the U.S. population depends on the representativeness of the specific data resources used in the study *(132,133)*. Most of the treatment studies we discussed were conducted in selected SEER areas of the United States that include large urban populations and the major racial/ethnic groups. However, because these treatment studies rely on data obtained from medical and/or administrative records, the

important elements of individual patient preferences, physician practice styles, health care delivery settings and other organizational factors *(83)* are often absent.

Data from cancer registries are used for studies of cancer treatment because they are population-based and contain accurate and detailed information on the date of diagnosis and tumor stage at diagnosis. The collection of data on the first course of treatment is required by both SEER and NPCR. Treatment data, especially data on adjuvant chemotherapy and hormonal therapy given outside the hospital setting, require extra resources to collect. Studies of registry data augmented by physicians' office records or by linkage with databases such as SEER-Medicare have found that information for treatments given in the hospital (i.e., surgery and radiation therapy) is reasonably complete (i.e., greater than 90%), whereas information for adjuvant chemotherapy or hormonal therapy, which may be given outside the hospital setting, is somewhat less complete, perhaps about 75%, although this percentage may vary by type of cancer *(134–141)*. The NPCR *(141)* and NCI POC/QOC studies address these limitations, in part by re-abstracting the additional information for existing cancer registry cases. However, because such reabstraction studies are expensive, they are not conducted for all cancers or for all years of diagnosis.

Other approaches can be used to augment treatment data that are routinely available in cancer registries, such as the linkage of SEER to the Medicare database *(26,142)*. Linking SEER data to Medicare records has made it possible to construct an ongoing database that can provide a longitudinal history of all Medicare-covered services and procedures. Unlike POC/QOC data, the SEER-Medicare database lacks representative data for individuals younger than 65 years; information on many oral medications, such as tamoxifen; or detailed data for individuals enrolled in HMOs. Data from individual, large, non-profit HMOs in SEER areas can help to fills these gaps, but these data may not be representative of the broader universe of managed care delivery systems *(143–145)*.

Finally, because of the limitations described, many of the conclusions of treatment studies have to be considered as indicative rather than definitive, pending future studies designed to acquire more detailed data on disease severity, the presence of comorbid conditions, and patient and physician preferences and attitudes. Nevertheless, these treatment studies define our baseline level of "watchful concern" *(115)* and point the way for future directions.

Future Directions

The goal of basic and clinical research, cancer surveillance, and cancer control is to reduce suffering and death due to cancer. Supporting scientific research to increase knowledge about the molecular and cellular mechanisms that affect the initiation and progression of cancer can help lead to the development of more effective treatment modalities. The Institute of Medicine's 1999 report on the cancer care system *(8)* recommended efforts to ensure that evidence-based interventions for treating cancers are available and accessible to all cancer patients. The dissemination and adoption of research findings and evidence-based treatment guidelines can be facilitated through effective partnerships among clinical, public health, and cancer surveillance entities.

Monitoring the dissemination of advances in cancer treatment throughout the U.S. population is an important aspect of ensuring uniformly high standards of care. Population-based cancer registries provide a foundation for such monitoring and can be used to provide important, albeit incomplete, information about the effectiveness, adoption, and dissemination of cancer treatment. The cancer registry-based data and related resources that we have reviewed in this article raise substantial concerns that the treatments cancer patients receive may depend on nonclinical factors, such as the race, socioeconomic status, age, and geographic location of the patient. The published cancer treatment studies are not definitive, though, because they do not adjust for factors that could affect the study results (e.g., the within-stage severity of patients' disease, patients' unmeasured morbidity, and how physicians and patients weigh the potential benefits and harm of various cancer treatments).

Using population-based cancer registries and related resources for the surveillance of cancer treatment is therefore complex. In recent years, national, multisite studies of newly diagnosed cancer patients—including the Prostate Cancer Outcomes Study and the study conducted by the Cancer Care Outcomes Research and Surveillance Consortium *(146)*—have collected additional data for patients sampled from cancer registries. These studies collected more complete information on the entire spectrum of cancer treatment, including the cancer patient's decision-making process, satisfaction with the treatment given, and quality of life subsequent to treatment, as well as characteristics of the physicians providing treatment and referral to specialists. Whenever possible, these cohorts have been linked to population-based registries and/or to large, organized health care delivery systems (e.g., Medicare and the Veterans Administration Health Care system) or large HMOs. A similar enterprise—the National Initiative on Cancer Care Quality—is now being conducted under the auspices of the American Society of Clinical Oncology *(147)*.

The resources developed and studies conducted to date have established a solid foundation on which similar efforts could be built in the future. The cancer surveillance community, including the ACS, the CDC's National Center for Health Statistics and NPCR, the NCI's SEER Program, and the NAACCR *(114)*, have built strong partnerships with each other, as well as with entities such as the AHRQ, the Centers for Medicare and Medicaid Services, and others. These partnerships enable the sharing of complementary data collected in each system to contribute to our knowledge about the cancer burden in the United States. Placing a high priority on continuing this effort, as well as on developments in medical informatics and the electronic medical record, and the adoption of standardized messaging and vocabularies *(148)*, may facilitate monitoring of the translation of basic science and clinical advances to cancer prevention and detection and uniformly high-quality care in all areas and populations of the United States.

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NOTES

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